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AUTHOR	Manis, Jean D.; And Others
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ABSTRACT

Women have traditionally not entered the fields of science and mathematics. This study examines survey responses of University of Michigan seniors interested in science for factors associated with the attraction away from the sciences among women, and reasons why they are more attracted to other fields. The survey respondents were senior women (n=213) who had responded to a science interest questionnaire as freshmen, senior women (n=85) who had not responded to the questionnaire as freshmen, and senior men with similar backgrounds in science (n=124). Women and men respondents were classified as either science concentrators or humanities and social science concentrators. Data presented in this report are based on comparisons among these four groups, or combinations thereof. The first section of the report compares the high school experiences of these groups. The second section compares the university experiences of these groups. Experiences are described by year from the freshman to senior year. Other comparisons are reported concerning educational and career plans, interpersonal influences on career plans, impact of affiliative relationships and family plans, and attitudes about science and careers. Conclusions are discussed about women's enrollment in science and mathematics courses, affective aspects of learning, lack of contact with women in scientific fields, parental influences in the decision to study science, the importance of science in career plans, and combining family and career roles. Six recommendations to increase women's enrollment in science are made. (Contains 22 references.) (MDH)

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Adult Development Research Program

Research Report #23

An Analysis of Factors Affecting Choice of Majors in Science, Mathematics, and Engineering at the University of Michigan

Jean D. Manis
Nancy G. Thomas
Barbara F. Sloat
Cinda-Sue Davis

U.S. DEPARTMENT OF EDUCATION
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An Analysis of Factors Affecting Choice of Majors in Science, Mathematics, and Engineering at The University of Michigan

One of the continuing anomalies in American education is the tendency for women to take fewer mathematics courses in high school than men, and to be less apt to choose science majors in college. Over the last 20 years, considerable attention has been paid to the factors affecting women's achievement in mathematics, by educators and others interested in expanding opportunities for women. More recently, this interest has become linked with a more general concern about the quality of science education and the number of students interested in careers in science. Projections based on current demographic trends point to a potential shortage of trained personnel in science and technology for the 1990's and beyond (U.S. Congress, Office of Technology Assessment, 1985). The population of 18- to 22-year-olds is expected to drop 12 to 16 percent by 1995. Furthermore, the proportion of entering college students interested in science has been declining. The college-age population of the future will include a larger proportion of students from ethnic groups that historically have been less likely than white males to go into science. And while the number of women in the sciences increased dramatically in the 1970's and early 1980's, that movement appears to have reached a plateau, and may actually be declining in certain fields (Vetter, 1987). Thus, unless more students are attracted into the sciences, particularly from groups that are currently underrepresented, the projected shortfall of scientists may be severe.

There are, of course, differing interpretations of what current trends suggest for the future. The OTA (1985) assessment argues that market forces affect the proportion of science baccalaureates who seek doctoral degrees, for example, and that shortages may be met by substitutions or changes between fields. Others believe that the proportion of college students who choose to study science is relatively stable, and not particularly susceptible to market influences (see Finkbeiner, 1987, for a discussion of these contrasting viewpoints). If, however, substantially greater numbers of women might be attracted into science, given certain changes, then the assumption that the proportion of students entering science is relatively fixed--at the level that has obtained in the past--is in error, and leads to faulty projections. It becomes important, then, to give further attention to the factors that seem to be associated with attrition from the sciences among women, and to the reasons why they are more attracted to other fields.

In her 1988 presidential address to the American Association for the Advancement of Science, Widnall (1988) described the pipeline that funnels students into careers in science: A cohort of 2000 female and 2000 male ninth grade students will include roughly 280 men and 220 women students who will complete enough high school mathematics to undertake a college-level concentration in science; of those 500, only 140 men and 44 women entering college will choose to concentrate in science, and 46 men and 20 women will receive their baccalaureate in science; of these, just 5 men and 1 woman will eventually earn a science-related Ph.D. Thus there seem to be two major points where women differentially move away from the study of science--in the likelihood of selecting a science major, and in the completion of graduate degrees. (According to this model of the pipeline, among those who have sufficient high school math to do so, only 20% of the women, compared to 50% of the men, choose to major in science; among those who receive baccalaureate degrees in science, men are twice as likely as women to go on to earn doctoral degrees in science). On the other hand, among those students who select a science major in college, women are more likely than men to complete their baccalaureate degree. What factors are responsible for these gender differences? In particular, what happens during the first year of college that influences the choice or rejection of science as a field of

study? Among those who choose science majors, what factors influence decisions about graduate training and subsequent careers? The study described in this report was designed to provide at least partial answers to these questions.

Description of Study

In the summer of 1983 the Women in Science Program at The University of Michigan contacted all incoming freshwomen who either indicated an interest in science or math in their applications for admission, or who had quantitative SAT scores of 550 or higher, to ascertain their educational interests and career intentions prior to matriculation and to invite them to attend a Women in Science workshop in the fall. Approximately 1500 women received the brief questionnaire; of these, 530 women responded. These respondents were recontacted during their senior year, to see how their plans had developed or changed since their first year--in brief, to assess the effect of the undergraduate years at U-M on their career plans, particularly with respect to scientific careers.[1] In March, 1987, a 15-page questionnaire was sent to three groups: all women who had returned the 1983 survey who were enrolled as seniors in 1986-87, a sample of women who had received the 1983 survey but had not responded, and a sample of senior men who met the same criteria as freshmen, with respect to the quantitative SAT score. In all, 1210 questionnaires were mailed: 434 to women who responded in 1983, 280 to women who had not responded in 1983, and 496 to senior men who met the 1983 qualifications of the incoming women surveyed by the WIS program that year.[2]

Responses were received from 422 students: 213 women who had responded to the 1983 survey, 85 women who had not responded in 1983, and 124 men. (However, two of the male respondents did not provide enough information to ascertain their field of concentration, and hence were not included in the analyses.) Gross response rates were thus 49% for the earlier respondents, 31% for the former non-respondents, and 26% for the men. However, these figures probably underestimate somewhat the true response rate, since it is unlikely that all questionnaires actually reached the intended recipient (because of frequent changes of address among students). Reminder postcards were sent two to three weeks after the original mailing. Undoubtedly, those recipients who were not science majors and had never been interested in science were less apt to return the questionnaire; although the questions covered the plans and experiences of all students, emphasis was placed on the factors affecting whether or not a respondent was interested in science.

With respect to race, 91% of the respondents were Caucasian, and 5.5% were Asian-American; there were very few other minority students among the respondents--1% were Blacks, 2% Hispanic, and less than 1% Native Americans. The science concentrators included a higher proportion of Asian-American students than the non-science concentrators, with the greatest difference among the women: 10% of the women in science, compared to 3% of the non-science women, were Asian-Americans.

In this report, references to "science," "scientific fields," or "science concentrators" should be understood to include all physical and natural sciences, mathematics, and engineering. For the purposes of this report, the social and behavioral sciences such as psychology and anthropology are included with the social sciences.

For purposes of analysis, the 420 respondents were divided into four groups: women who had selected fields of concentration in the humanities or social sciences (N=186); women who were science concentrators (N=111); men who were humanities or social sciences concentrators (N=52); and men who were science concentrators (N=71).

The data presented in this report, which are primarily descriptive in nature, are based on comparisons among these four groups, or combinations of them.

In the first section of this report, we will compare the pre-college educational experiences of these four groups of respondents. Other sections will describe the respondents' experiences at Michigan, their career plans and attitudes, parental characteristics, their attitudes about science courses and careers, and their views about the adequacy of academic counseling at UM. The findings presented in this report are based solely on the 1987 survey; they do not include data collected in 1983.

High School Experiences

Over two-thirds (69%) of the respondents described the community in which they lived during their high school years as "suburban," with essentially no variation among the four groups (67% to 71%); 19% described their community as "small town," with even less variation among the groups. The other two response options--"urban" and "rural"--were each checked by 6% of the respondents. More than half (53%) graduated in classes with 300-599 students, with 28% describing their class size as 100-299; again, there did not appear to be marked variation among the four groups.

Respondents were asked whether they had taken any advanced placement courses in high school, whether they had taken advanced placement exams, and whether they were exempted from any courses on the basis of those tests when they enrolled at Michigan. The courses mentioned were then categorized as falling within the humanities or social sciences, foreign languages, math, or sciences (see Table 1.) As might have been expected, the science students were more apt than the non-science majors to have taken advanced placement courses in math and science, to have taken advanced placement exams in those subjects, and to have been exempted from relevant courses at U-M. In addition, a larger proportion of them had also taken advanced placement courses and exams in the humanities and social sciences, and had been exempted from humanities courses at Michigan. With respect to foreign languages, the sex difference was more striking than any science/non-science difference: women, whatever their field, were more likely than men to have taken advanced placement courses and exams in foreign languages, and to have been exempted from relevant foreign-language courses at Michigan.

Another sex difference was apparent in the percentages of students who had taken advanced placement courses in mathematics: among both science and non-science students, women were less apt to have taken advanced placement math courses, or to have taken the advanced placement exams, or to have been exempted from math courses at U-M. Among the science concentrators, however, the women were just as likely as the men to have taken advanced placement science courses and advanced placement tests in science, and were just as likely to have been exempted from science courses at Michigan.

Respondents were asked whether, prior to coming to the University of Michigan, they had had any experiences which had tended to foster or to discourage an interest in science or math. Over 90% of the science concentrators reported having had such positive experiences (94% of the women, 91% of the men), but most of the non-science concentrators also reported positive experiences (66% of the women, and 73% of the men). The positive experiences mentioned most frequently--having had good courses or good teachers, having done well, having enjoyed the courses, and having been encouraged by teachers to pursue those subjects--tended to be cited more frequently by women than by men; among the women, there was little difference by field. Two other experiences--

having won awards or prizes in math or science, and having participated in special clubs or activities in those fields--were mentioned by a larger percentage of men than of women.

With respect to negative experiences prior to enrolling at U-M, the non-science concentrators were more likely to report factors that had dampened their interest in science, or had discouraged them from considering a career in science, with little difference between the men and women (41% of the women, and 38% of the men). Among the students in science, a larger proportion of women than men reported negative experiences: 23% of the women, compared to only 14% of the men. Most frequently mentioned as discouraging factors were poor high school courses or teachers, not enjoying the material, and not doing well. Interestingly, women in scientific fields were less likely than men in science to say that they didn't do well in math or science courses, or that they did not enjoy those courses, or that they were not sure they were interested in science as a field. Presumably, such reactions were experienced as frequently by women as by men; if so, the deterrent effect of such experiences must have been greater for women than for men, with respect to pursuing science as undergraduates. (That is, women who did not do well in high school math or science courses, or who did not enjoy those courses, were apparently less likely than men who had similar experiences to become science concentrators as undergraduates.)

Factors Affecting Attitudes at First Enrollment

Respondents were asked to recall how important each of 11 items had been as factors influencing their thinking about possible fields of study, at the time they first enrolled at Michigan (see Tables 2, 2A, and 2B). Each item was rated on a five-point scale (1=Not at all important, 5=Very important).

Overall, the factors generally regarded as important (i.e., rated as 4 or 5 by at least half the students) were these: personal enjoyment and interest in the subject (89%), the student's own talent in the field (79%), high school course (70%), importance of the subject as preparation for intended career (68%), having a strong background in the field (51%), and family member (50%).

Mean ratings of the 11 factors, for each group, are shown in Table 2A, together with the results of significance tests. Students in the sciences rated the influence of family members, high school teachers, and high school courses as significantly more important than did students in other fields. (With respect to high school courses, for example, 69% of the science students, compared to 52% of the non-science students, gave this source of influence a rating of 4 or 5.) Science students also rated having a strong background in the field, and the importance of the field as preparation for their intended career, as significantly more important than did the non-science students. Students in the humanities and social sciences rated volunteer experience as significantly more important, and also tended to give more importance to work experience. On the other hand, the sense of personal enjoyment and interest, the only factor which was given a rating of 5 by a majority of each of the four groups, showed little differentiation among the groups.

The importance of their own talent in the field was stressed most by men in science. The most striking difference occurred in the proportion assigning this factor a rating of 5: 51% of the men in science, compared to 37% of the women in science, and 35% of the women and 31% of the men in other fields. Similarly, men in the sciences were much more likely to assign a rating of 5 to having a strong background in the field--37% did so, compared to 19% of the women in science, and 17% of the men and 14% of the women in other fields.

Respondents were asked if they had had a field of interest in mind when they first enrolled at U-M, and if so, what field (or fields). If we use the items discussed above to predict whether a student was interested in science at the time he or she first enrolled in college, we obtain much the same pattern of results: Family members, high school teachers, other adults, high school courses, having a strong background in the field, and the importance of the field as preparation for a career were all rated significantly more important by those students who indicated they were considering a major in science when they first enrolled. Personal enjoyment and interest was rated as significantly less important by those who were considering a major in science. Volunteer and work experience were not significant predictors, but tended to be rated as more important by those who were not interested in science.

After rating how important each of the 11 items were as influences when they first enrolled, respondents were asked to select the factor that had been the most important influence on their thinking at that time, and the second most important. Science and non-science students showed strikingly different patterns when naming their most important influence. Overall, 43% of the students said that personal enjoyment and interest was the most important factor in their thinking; however, science students were less likely to give this response than were other students. Women in science were the least apt to name this factor (30%), followed by men in science (41%); 48% of the women in other fields, and 56% of the men, chose this factor. A corresponding imbalance was evident on the second most common choice: 16% of the students said that the importance of the field as preparation for their intended profession or career was the most important factor, with science students more likely to give this response. Women in science most frequently made this choice (24%), followed by men in science (17%), women in other fields (13%), and men in other fields (10%). Students in science were also more likely to say that a family member had been the most important influence: 15% of the women and 13% of the men, compared to 9% of the women and 6% of the men in other fields, made this choice.

Their own talent in the field was chosen most frequently, overall, as the second most important influence. Men in science, and women in other fields, were the most likely to make this choice: 30% of the men in science, compared to 15% of the men in other fields, and 27% of the non-science women, compared to 20% of the women in science.

It would appear, then, that by the time they entered college, students who ultimately selected a field of concentration within the sciences were more influenced by career considerations, and less by personal enjoyment of the subject matter, than was true for students who selected non-science concentrations.

Experiences at University of Michigan

Respondents were asked whether they had had a field of concentration in mind when they first enrolled at U-M. Of the 420 respondents, 100 said that they did not have a field in mind; 209 had a science field in mind, 100 had a non-science field in mind, and 11 said that they were considering both a science and a non-science field. Thus, of those who had a field in mind, 65% mentioned only a scientific field, and 3% mentioned both a science and a non-science field, for a total of 69% who were considering going into science. However, only 48% of those who had had a field in mind to begin with actually chose a field of concentration in math or science. (Of those who had no field in mind when they first enrolled, 29% ultimately chose to concentrate in the sciences.) Of those who said that they had initially been interested in a non-science field, only one student eventually chose to concentrate in science--a male student who switched from economics to computer

science. Thus there is a considerable movement away from science majors during the years at Michigan, with no corresponding attraction into scientific fields of students who were initially interested in other fields. A major goal of this study is to explore the factors which appear to account for this imbalance.

The attrition from science was more marked among women than men. Of the 144 women who were initially interested in science, 65% became science concentrators, and 35% chose other fields; among the men who were initially interested in science, 76% became science concentrators, while 24% ultimately chose other fields. Table 3 shows the breakdown of the four student groups by their initial area of interest. In order to explore the possible causes of attrition among women, on key issues we will compare the 50 women who chose not to pursue their initial interest in science with the 94 women who did so. We will also look at such comparisons among the men; however, since there are only 18 men who did not pursue their initial interest in science, any conclusions about the factors affecting attrition among men will necessarily be very tentative, as will any comments about sex differences with respect to factors related to attrition.

Respondents were asked a series of questions about their academic experiences at Michigan during three periods: their first year at Michigan, their second year, and their third and fourth years, together. Specifically, they were asked whether there were particular courses that had strengthened, or weakened, their interest in science; whether their academic advisors had either encouraged or discouraged them from taking science or math courses, and whether they had had any other experiences that tended to affect their attitudes about science or their thoughts about possible careers. Their responses for the three periods are summarized below. We will give most attention to experiences during the first year, since for most respondents these experiences are presumably most influential in affecting choice of field.

First-Year Experiences

Respondents were more likely to report having had courses during their first year which dampened their interest in science than they were to say that they had had courses which increased their interest in science: overall, only 26% reported such positive effects, while 61% had taken courses which had a negative impact. Students in science were significantly more likely than other students to report positive course experiences, but they were no less likely to report negative experiences; indeed, the proportion of respondents reporting negative experiences was largest among the women in science (71%, compared to 59% of other women, 54% of men in science, and 57% of other men).

Courses in chemistry and mathematics were mentioned most frequently as both positive and negative experiences, which reflects the fact that these courses were taken by a large number of students; they are pre-requisites for further study in virtually all fields of science. Again, however, these subjects were mentioned more frequently as having provided negative experiences. In all, 127 respondents mentioned a chemistry course as having had a discouraging effect, and 124 mentioned a math course. (By contrast, only 26 students mentioned a physics course, 13 mentioned an engineering course, and 11 mentioned a biology course.) Cited most frequently as having had a negative effect were Chemistry 123 or 124, and Mathematics 115 (calculus): 93 respondents, or 73% of those who mentioned a chemistry course, specifically cited Chemistry 123 or 124, and 88 respondents, or 71% of those who cited a math course, specifically mentioned Math 115. In all, of respondents who reported courses which had had a negative impact, 39% mentioned one or both of the chemistry courses, and 36% mentioned the math course.

Respondents were asked to explain how the courses cited as having had a positive or a negative impact had influenced their attitudes about science. Among the respondents who cited courses which had had a negative impact, 38% felt that the courses were poorly taught--that they were badly organized, or that the TA created problems, or did not speak English very well, or that the instructor took no personal interest in what the students were learning, or having problems with. Thirty percent said that the material was hard or confusing, or that they did not do well in the course, or that they lost confidence in their ability to pursue that type of subject matter.

Twenty-one percent commented that they did not like the atmosphere in the class--that it was too competitive, or cut-throat, and that the courses appeared to be designed to weed out students rather than encourage them. Fifteen percent said that the material was dull, boring, too dry. Thirteen percent said that they just didn't like the subject matter. And 10% specifically commented that they disliked the grading system: they felt that it did not accurately reflect what they had learned, but rather appeared to be intended to weed out students. There were many references to the aggressive competition among pre-med and engineering students, as creating an atmosphere that was unpleasant and unfriendly, and in contrast to courses in other fields.

The types of negative influence cited by those who listed the chemistry or calculus courses followed much the same pattern, with somewhat more emphasis on certain aspects: With respect to the early chemistry sequence, 29% (as opposed to 21% overall) said that they disliked the atmosphere in the class, and 14% (compared to 10% overall) said that they disliked the grading system.

With respect to sex differences, there were three noticeable differences in the comments made by respondents who had taken courses which discouraged them or dampened their interest in science: Women were more likely than men to say that they disliked the competitive atmosphere in class (24% vs. 11%); women were more likely to say that they disliked the grading system (12% vs. 5%); and men were more likely to say that they found the subject matter dry or boring (24% of the men, vs. 11% of the women).

When the women's negative comments referred to Chemistry 123 or 124, there were more mentions of the unpleasant class atmosphere (33% did so, compared to 18% of the women whose responses referred to other courses which had had a negative impact), and there were also more references to the grading system (17%, compared to 9% of the women who mentioned courses other than Chemistry 123/124). Among the men, the chemistry sequence, more often than the calculus course, was described as having been poorly taught: 48% of the men who cited Chemistry 123 or 124 as one of the discouraging courses, but only 30% of those who cited Math 115, gave this reaction. The math course, however, was more often cited as difficult by the men--35% offered this description, whereas only 16% of the men so described the chemistry course. Among the men, the description of "dry, boring," was more likely to be applied to the chemistry course than to the math course: 32% so described the chemistry course, compared to 17% who gave this reaction to the math course.

Did these negative reactions to their first-year experiences affect the respondents' subsequent choices about pursuing scientific study? We divided those who indicated that they were thinking about concentrating in the sciences when they first enrolled into two groups, those who later chose a science concentration and those who chose a field of concentration in the humanities or social sciences. Among those students who cited Math 115 as a negative influence, those who ultimately chose a non-science major were more likely to report that they had found the material difficult--36%, compared to 23% of those who remained in the sciences. Among the women, 33% of those who majored in non-

science fields, compared to 19% of the science majors, gave this reaction. However, believing that the course was poorly taught, or disliking the atmosphere in the class, were reactions more frequently mentioned by those who remained in the sciences. And among the women who mentioned Math 115 as a discouraging experience, those who stayed in the sciences were more likely to describe the course as dry or boring than were those who chose non-science majors.

Among those who cited Chemistry 123 or 124 as a negative influence, those who thought that the course was poorly taught, those who found it difficult, and those who disliked the class atmosphere were less likely to have chosen fields of concentration in the sciences. If we look only at attrition among the women, the differential effect of finding the subject difficult disappears, but the effect of poor teaching and of class atmosphere remain at about the overall levels. By contrast, finding the material dry or boring, and, to a lesser extent, disliking the subject matter, were reactions mentioned more often by those who remained in the sciences.

It should be noted that those who ultimately chose a non-science field, despite an initial interest in science, were apparently less committed to science in their first year than were those students who remained in science: of those students initially interested in science, only 30% of those who later decided on non-science fields, compared to 76% of those who became science concentrators, took five or more science or math courses in their first year. It seems reasonable to assume that those students with clear career goals in scientific fields were the most likely to take several science courses their first year. It may be, therefore, that those with clear career goals were less apt to be discouraged by any negative experiences they may have encountered, whereas those who had less clear goals may have seen no compelling reason to continue with studies which presented the problems outlined above.

Respondents were asked how they felt, at the end of their first year, about taking more science or math courses. Among those who indicated they had initially been interested in science, 72% of those who subsequently chose a non-science concentration said that they were less interested in science than they had been, whereas 70% of those who subsequently became science concentrators said that they were as interested, or more interested, than they had been. Thus experiences during the first year appear to have a crucial influence on student attitudes about science.

It should also be noted that students, men and women, who did not pursue an initial interest in science were significantly less likely than those who majored in science to have taken advanced placement courses and advanced placement tests in science and math in high school, and were less likely to have been exempted from introductory science and math courses at U-M (see Table 4). Thus, those who pursued their interests in science were apparently better prepared to do so, on the basis of their high school education, than were those who later chose other fields. (The fact that they were more likely to have been exempted from the basic introductory courses that many students found unpleasant may also have influenced their subsequent decisions--that is, more of them avoided an experience which apparently discouraged many students.) Whether this difference in high school preparation reflects a difference in ability, as opposed to differences in availability of such courses, family emphasis on academic achievement, or other such factors, we cannot determine from our data. One clue might be found in the proportion of students who were invited into the LS&A Honors Program at Michigan when they first enrolled. If we exclude the students in Engineering, which has no such program, men who did not pursue an initial interest in science were just as likely as those who did to have been invited to join the Honors Program. Among the women, those who left science were less apt to have

been asked to join the Honors Program than were the women who became science concentrators.

In discussing their reactions to courses which they felt had had a positive effect, with respect to encouraging an interest in science, students commented that they liked the course, or that the material was interesting, that it increased their interest in that field, or made them want to take more courses in the field, etc. A smaller number of respondents commented that having done well in the course cited encouraged them to consider taking further courses in the same field. A variety of courses were mentioned as having provided positive experiences, with no concentration on any particular course or discipline.

Respondents were asked whether there were other experiences during their first year, aside from their math or science courses, which had affected either their attitudes about science or their thoughts about possible career choices. Forty-one percent, or 168 students, indicated that they had had such experiences. (Nearly half, or 48%, of the women in non-science fields gave this response, as did 41% of the men; 38% of the women in science reported such experiences, compared to only 29% of the men in science.) Of those who reported such experiences, 52% cited influences that could be categorized as negative reactions to the study of science, or the pursuit of scientific careers; 36% cited experiences which resulted in positive reactions to other fields; 22% cited experiences which fostered positive attitudes toward science; and four percent cited negative reactions to other fields. Thus, responses were more apt to refer to negative aspects related to the study of science, rather than to the positive attractions of other fields. The most common negative aspects, which were mentioned primarily by non-science students, included the following: (1) Students observed that many of their friends or roommates who were taking science courses were not enjoying them, or they were working very hard, or they felt the courses took too much time; (2) Respondents reacted negatively to the competitive atmosphere in science and math classes; (3) Respondents decided against science or math as a career field, as being too narrow or technical, or not allowing for other interests and activities; (4) Respondents were sometimes discouraged about taking more science or math courses, because they feared that they had less ability or aptitude for the field than other sci/math concentrators.

Second-Year Experiences

When asked about their experiences during their second year at Michigan, respondents were again more likely to say that they had had courses that discouraged an interest in science, than they were to say that they had had courses which fostered an interest in science. Thirty-seven percent of the students--including 58% of the science concentrators, but less than 20% of the other students--reported having had courses that encouraged them; 43% of the respondents, ranging from 37% of the women in non-science fields to 52% of the women in science, reported having had courses that discouraged them. (There was no difference by field among the men; 43% of the men in science, and 42% of those in other fields, reported such negative experiences.)

When citing courses that had had an encouraging effect during their second year, 16% of the respondents mentioned Biology 112, and another seven percent mentioned other biology courses. Ten percent mentioned mechanical engineering, and nine percent cited other engineering courses. Nine percent mentioned organic chemistry. Among the courses that had had a discouraging effect, three courses were mentioned most frequently: Organic chemistry, Math 216, and Physics 240, each of which was cited by 10% of the respondents, primarily the science concentrators. Among the students in science, men and women were about equally likely to mention the chemistry and physics courses (14-16%, for each course) but men were much more likely to cite Math 216. (Women may have been

less apt to have taken this course.) Women in science, however, were more likely to cite Physics 140 than men; perhaps men were more likely to have taken this course during their first year. Responses describing how the courses had affected the students were similar to those reported above, in the discussion of the students' first-year experiences.

Respondents were also asked, with reference to their first and second years at Michigan, whether their academic advisors had either encouraged or discouraged them from taking math or science courses. Very few students reported having been discouraged from taking such courses--7% in the first year, and 2% in the second. While 31%, in the first year, and 16%, in the second year, said that they had been encouraged, the overwhelming response was "neither;" 62% of the respondents, describing the first year, and 81%, describing the second year, gave this response. Students in science were more likely to report having been encouraged, in both years. Respondents were invited to comment about the role of the academic advisors; 240 did so following the question about the first year, and 152 did so about the second year. Concerning the first year, 25 respondents said that they didn't talk to an advisor, or had very little contact; 23 said that they knew what they wanted to take, and hence didn't need advice; 41 commented that the curriculum in their program was pretty well set, and there was little room for choice (a response given most frequently by students in Engineering); and 41 made negative comments about the inadequacy of the academic counseling process. These negative responses included such comments as the following: "What counselor?" "The advisor took no personal interest in me." "I felt like a number." "The counselors don't know enough about the courses to be helpful." Other responses included neutral ("The advisor just explained what was required") or positive reactions (that the counselor was supportive of the respondent's interests, for example), but these reactions appeared less frequently. Comments about the counseling process during the second year were very similar.

Experiences During Third and Fourth Years

Students who did not concentrate in science were less apt to mention courses that discouraged or encouraged an interest in science during their junior and senior years, because they were no longer taking such courses. Among the students in science, responses concerning courses that had had an encouraging or a discouraging effect mentioned a wide range of courses, with no marked singling out of any one course. Those who cited positive experiences tended to comment that they found the subject matter more interesting as they were able to take courses in areas they wished to pursue, in contrast to the more general early introductory courses.

Factors Affecting Choice of Field of Concentration

Respondents were again presented with a list of possible influences on their thoughts about a field of study, and asked to rate the importance of each factor with respect to their final choice of a field of concentration. Again, a five-point scale was used (1=not at all important; 5=very important). Table 5 shows the percentage of each group who gave a rating of 4 or 5 to each item. (Mean ratings of the items, and results of significance tests, are shown in Tables 5A and 5B.) More than 90% of the respondents rated "personal enjoyment and interest" as an important influence. Other factors rated by most students as important were the student's talent in the field (79%), college courses (77%), and the importance of the field as preparation for the student's intended career (69%).

When we used these items to predict whether a student had chosen a science concentration or not, a pattern of relationships emerged which was somewhat different from that obtained in the earlier analyses (of influences at the time of first enrollment). Only one item was rated as significantly more important by those who concentrated in

science--the importance of the field as preparation for a career. Five items were rated as significantly more important by the non-science concentrators: teachers, college courses, volunteer experience, their own talent in the field, and personal enjoyment and interest.

Among the students in science, men rated having a strong background in the field as significantly more important than did the women, and women rated the importance of the field as preparation for a career as significantly more important than did the men.

After rating all 11 items, respondents were asked to select the two factors that had been the most important and the second most important influences on their choice of a field of concentration. They most frequently chose their own personal enjoyment and interest: 43% gave this factor as their first choice, and 21% named it as the second most important influence, or a total of 63% naming it as one of the two most important influences. Fifteen percent said that college courses were the most important influence, with another 15% naming this factor as the second most important factor. The importance of the field as preparation for their chosen career was cited as most important by 15%, and by 14% as the second most important influence. Nine percent of the respondents said that their own talent in the field was the most important factor, with 17% citing this factor as the second most important influence. Work experience was named by 5.5% of the respondents as the most important and as the second most important factor.

Science concentrators were significantly less apt than other students to cite personal enjoyment as the most important influence: 31% of the men in science, and 39% of the women, did so, compared to 48% of both men and women in other fields. (However, science students were more likely to mention this factor as the second most important influence. Therefore, if we combine choices of "most important" and "second most important" influences, the difference is less striking: roughly 60% of the science majors, compared to 67% of the students in other fields, named personal enjoyment as one of the two most important influences.). The science students were significantly more likely than others to say that the importance of the field as preparation for their chosen career was the most important influence in their choice of a field of concentration. In particular, women in science mentioned this factor more frequently than other students as both the most important influence and the second most important; if we combine the two choices, 46% of the women in science chose this factor, compared to 30% of the men in science, 29% of the men in other fields, and only 19% of the women in other fields.

Students in humanities and social sciences were more likely than those in science to name their own talent in the field as one of the two most important influences: 33%, compared to 18% of those in the sciences. Women in the sciences were the least apt to cite this factor--only 14% did so, as either the first or second most important influence. With respect to the importance of college courses as an influence on choice of field, there was little difference between the groups in their selection of this factor as most important (15%, overall), but a higher proportion of women than men named this factor as the second most important influence (18% vs. 11%).

Is there a relationship between the most important influences on the student's choice of a field of concentration, and attrition among science students? In particular, what might such a relationship tell us about women's selection or rejection of careers in science? Again, we divided those students who reported an initial interest in science into two groups, those who later chose a field of concentration in the sciences and those who chose other fields. There is a striking difference between the women in these two groups: 47% of those who remained in the sciences, but only 18% of those who chose other fields, named the importance of the field as preparation for their chosen career as either the most important or the second most important influence on their choice of a field of study.

Women who chose other fields were more likely to cite their own talent in the field as a major influence (28%, vs. 16% of the women in science), and slightly more of them named personal enjoyment and interest (66% vs. 60%), and college courses (34% vs. 29%), as top influences.

Educational and Career Plans

Sixty-five percent of the respondents said that they intended to go to graduate or professional school, and another 23% indicated uncertainty about whether they would pursue further education. Women in science were the most likely to say that they intended to seek further schooling--71%, compared to 66% of the men in science, 63% of the women in other fields, and 58% of the men in other fields. The degree most frequently intended, by all groups, was the MBA: 37% of those who listed possible higher degrees mentioned the MBA, ranging from 35% of the women in humanities and social sciences to 43% of the men in science. Twenty percent of the respondents said that they might want to earn a Ph.D.; women in science mentioned this degree most frequently (25%, compared to 18% of the men in science). Thirteen percent of the respondents were interested in earning an MD--23% of the women and 21% of the men in science, and 5% of the students in other fields.

With respect to when they intended to begin their graduate study, 34% of the respondents indicated that they intended to go on immediately; 46% said that they would continue after a year or two; and 19% said that they would wait for several years before pursuing further education. A higher proportion of the men in science than of any other group said that they would begin immediately--42%, compared to 37% of the women in science, 32% of the men in other fields, and 28% of the women in other fields. Among the science students, 45% of the women, and 41% of the men, said that they would begin their graduate or professional education after a year or two; only 16-17% of the science students said that they intended to wait several years before continuing their education.

When we looked at when the respondent intended to pursue graduate education by area or specific degree in question, the pattern of responses suggested a gender difference, with a higher proportion of men saying that they intended to begin their graduate education immediately. For example, among the 46 respondents who mentioned earning an MD (28 women and 18 men), 83% of the men, compared to only 68% of the women, said that they intended to go on in the next year (or were already in medical school, in the Inteflex program); 32% of the women, compared to 17% of the men, said that they intended to go on after a year or two. Of the 136 respondents who mentioned an MBA, 23% of the men and 15% of the women said that they intended to go on immediately; 60% of the women, compared to 48% of the men, said that they would go on after a year or two. Among the 45 respondents who mentioned possibly earning a law degree, 36% of the women, but 56% of the men, said that they would continue in the next year; 50% of the women, and 44% of the men, said that they would continue after a year or two. Of the 72 respondents who mentioned earning a Ph.D., 45% of the women and 55% of the men said that they would go on the following year; 12% of the women, but only 5% of the men, said that they would continue after several years. However, none of these differences with respect to when the respondent intended to begin graduate school achieved statistical significance.

Among the students currently in the School of Engineering, there were gender differences with respect to both certainty about pursuing further degrees, and timing of the further education. Among the men, 61% said that they intended to earn an advanced degree, with 29% indicating uncertainty; among the women, 44% said that they intended to

earn an advanced degree, and 43% indicated uncertainty. Thirty percent of the men who were considering further education said that they would continue in the next year, with 47% intending to go on after a year or two, and 21% after several years. Among the women who were considering further degrees, nine percent said that they intended to continue the next year, 59% said that they would continue after a year or two, and 31% said that they would continue after several years.

It should be noted that, among the women, attrition from the sciences was not primarily related to a lack of interest in pursuing graduate education. Among those women who indicated an initial interest in science, 69% of those who majored in science and 74% of those who chose other fields of concentration indicated that they were planning to go to graduate or professional school. As to when they expected to begin their graduate education, 33% of the women in science, and 37% of those in other fields, intended to continue their education in the next year; 44% of those in science and 53% of those in other fields said that they would continue after a year or two, and 19% of the women in science, compared to only nine percent of the other women, said that they would continue after several years.

It appears, therefore, that even though senior women may be considering the same professional degrees as their male classmates, fewer of them may be planning to proceed immediately with their graduate education. This pattern might reflect greater uncertainty about ultimate career goals, a lesser sense of urgency about reaching those goals, a reluctance to incur substantial debts to finance further studies, greater constraints related to affiliative relationships, or generally greater concern for other aspects of life. Whatever the explanation, such a hiatus in enrollment probably increases the extent to which other factors come into play, which may then determine whether the individual involved later applies for graduate school.

Respondents were asked to indicate how committed they were to the career plans they had described, using a five-point scale running from "Very uncertain" to "Very committed." Forty-three percent of the respondents rated themselves as 5's, at the "very committed" end of the scale, and 33% rated themselves as 4's. There was little difference among the four groups in the proportion rating themselves as 5's; however, women in science were more likely to rate themselves as 4's than were the other groups. If we combine the 4 and 5 ratings, 85% of the women in science, compared to 72-75% of the other groups, described themselves as fairly or very committed to their career goals. It would appear, then, that women in science may differ from men in science not in terms of commitment to their career goals, but rather in terms of the schedule they have in mind for reaching those goals. It may be that their anticipation of the problems related to integrating family and career roles, or to avoiding interference with their partner's career, leads them to foresee delays or interruptions in the course of their own career development.

We turn next, therefore, to a discussion of the impact on our respondents of family and other personal influences, including affiliative relationships and partnership plans.

Interpersonal Influences on Career Plans

After respondents had indicated what graduate degrees they wished to earn, they were asked who had had the greatest influence on their career plans thus far. By far the most common response, given by nearly half (47%) of the respondents, was "Myself"--or, "No-one." A larger proportion of men than of women gave this response; 54% did so, compared to 47% of the women in science, and 42% of the women in other fields. While

respondents may have been unaware of all the forces influencing them, or unwilling to report them, these responses nevertheless suggest that, within the range of fields they had considered, most respondents had felt free to choose whatever field they wanted.[3]

Roughly a fourth of all respondents said that a parent or other family member had been most influential. Ten percent of the respondents specifically mentioned their father, with only slight variation across the four groups: 13% of the men in science, and 11% of the women in science did so, compared to 9% of the women and 8% of the men in other fields. Less than three percent of the respondents (all women) specifically mentioned their mother, with no difference between women in science and women in other fields. Ten percent of the students said that a professor or other teacher (TA, etc.) had been most influential. Five percent of the women said that a partner--spouse, boyfriend, significant other--had been the major influence, a response given by none of the men. (Nine percent of the women in science gave this answer, and three percent of the women in other fields.) Six percent of the women, and three percent of the men, said that friends had been the major influence. Work experiences were cited by eight percent of the respondents, with the women in science least apt to give this response. (Women who indicated they had originally been interested in science, but who subsequently chose other fields, were more likely to cite work experiences than were the women who remained in science--12% vs. 6%. This difference, though small, perhaps reflects the fact that there are few opportunities for undergraduates to get practical experience in scientific work settings, and thus to develop an interest in a scientific field in ways other than through the classroom.)

Perceived Parental Goals

Differential influences on women and men as undergraduates are also shown in the responses to two questions which tapped parental desires: "How would you describe your mother's hopes and goals for you today?" and "How would you describe your father's hopes and goals for you today?" Responses indicating that the parent hoped that the respondent would be happy (e.g., be happy, be happily married, be happy in one's career) were given more frequently by women than by men. With reference to the respondent's mother, 55% of the women, but only 40% of the men, attributed such hopes to their mother. While fathers were slightly less apt than mothers to hold such wishes, according to our respondents' perceptions, they were still more apt to hold them about daughters than about sons; 45% of the women, compared to 37% of the men, attributed such hopes to their fathers. Parents no doubt wish for all their children to be happy, but these data indicate they are more likely to express such hopes as a goal to their daughters--that is, they are more likely to view "being happy" as a sufficient goal, or a necessary goal, perhaps in conjunction with other goals, for women.

The most commonly cited parental goal, attributed to 50% or more of both mothers and fathers, concerned educational or career achievement, either in general or with reference to pursuing a specific career. Men in humanities or social sciences more frequently than other students said that their mother held such goals for them (65%, compared to 47-51% of the other groups); women in science, more frequently than other students, said that their father held such goals for them (63%, compared to 53% of non-science women, and 57% of men). A larger proportion of men than of women perceived their mothers as holding the specific goal of being successful for them; with respect to fathers, men in humanities and social sciences were more likely to mention success as a goal espoused by their father. A slightly larger proportion of men in science reported generally phrased ambitions ("He/she has high hopes for me") as goals held by both parents.

Men in science appeared less likely than other respondents to say that either parent held family goals for them--that is, that they should get married, have children, and value their family role. These goals, of course, may have been taken for granted by the parents, and by the men in question, but they were apparently less focal goals for this group.

Parental goals which pertained to achieving successful relationships--to being happily married, to enjoying parenthood, to being happy in future relationships--were mentioned only by women. Again, parents may wish such outcomes for their sons as well as their daughters, but perhaps such goals receive less overt attention in the case of sons; career achievements and success may be seen as more primary goals.

Perceived Closeness and Similarity to Parents

Respondents were asked to indicate, by writing "mother" or "father" in the blanks provided, which parent they were closest to, which parent they resembled most in temperament, and which parent they resembled most in terms of interests and abilities. Nearly three-fourths (73%) of the respondents indicated that they were closer to their mother. (Seventeen percent said that they were closer to their father, and eight percent said they were equally close to both parents.) Students in the humanities and social sciences were most likely to say that they were closer to their mother--79% of the men, 77% of the women--but women in science were very similar in their response (73%). However, only 60% of the men in science gave this response. This is a rather striking difference, given the similarity of response across the other three groups. If closeness to mother in some way reflects sensitivity to affiliative relationships--mothers being frequently regarded as more involved in or more central to such relationships within the family--then men going into science may indeed be more distant or less concerned with interpersonal aspects of their work. (In exploring this finding, we noted that there were several men in science whose parents had been divorced and who indicated that they had lived with their father, after the divorce. To control for differences in relationships with parents which might have stemmed from factors related to parental divorce, we looked at responses to these questions among students whose parents had not been divorced. The results were essentially the same.)

In terms of temperament, respondents were more likely to say that they resembled their father--58%, with 36.5% indicating that they were more like their mother in temperament, and four percent saying they resembled both parents equally. With respect to temperament, there was little difference in the responses of the four student groups.

With respect to interests and abilities, 55% of the respondents said that they resembled their father more than their mother. Nearly a third (31%) said that they resembled their mother more than their father, and nine percent said that they resembled both equally. Among both men and women, students in science were markedly more likely to say that they resembled their father more than their mother--72% of the women in science, compared to 42% of the women in other fields, and 67% of the men in science, compared to 51% of the men in other fields. Correspondingly, students in non-science fields were more likely than students in science to say that they resembled their mother more than their father--39% of the women in other fields, compared to 20% of the women in science, and 36% of the men in other fields, compared to 23% of the men in science. Women in non-science fields were more likely than any other group to say that they resembled both parents equally (14%).

Parental Education and Occupation

The most striking fact about parental occupation is that students in science--particularly women--are more likely to have fathers and mothers in scientific occupations than are other students. Nearly half (48%) of the women in science and 41% of the men had fathers in scientific occupations, compared to 32% of the non-science students, men or women. With respect to their mothers, 22% of the women in science and 17% of the men had mothers in scientific occupations, compared to 11% of the other students, men or women. One field in particular gives evidence of a strong parental influence: of the students in science, 21% had fathers who were engineers, compared to 11% of the non-science students. (In contrast, science students were no more likely than other students to have fathers who were physicians.) Otherwise, there did not appear to be strong relationships between parental occupation and respondent's choice of field.

Only a limited amount of information was obtained about parental occupation and education. There were no clear relationships between parental level of education and respondent's choice of field. More than half of the fathers (53%) and nearly a third of the mothers (31%) had had some graduate work, with no major differences between groups.

Impact of Affiliative Relationships and Family Plans

Slightly more than half (52%) of the respondents described themselves as "single and unattached;" 38% described themselves as single but as having a significant other; eight percent were engaged; and one percent, or four respondents, were married. Women were more apt to be engaged or married than men (11% vs. 5%); men were more apt to be single and unattached (61% vs. 48%) The women in science were most apt to say that they had a significant other--44%, compared to 38% of the other women, and 34% of the men. Women in science were significantly more likely than men in science to have a current affiliative partnership--that is, to be married, engaged, or have a significant other.

Two questions asked directly about the impact on respondents' career plans of their concerns about family and affiliative relationships: "Are concerns about combining family and career affecting your decisions about what field you want to pursue?" and "Are you currently involved in a relationship that is affecting your plans for the future?" Each question was followed by the probe, "If yes, in what way?" More than a third of the respondents (36%) answered "Yes" to the first question: 43% of the women in science, 37% of the women in other fields, and 28-29% of the men, whatever their field. (Both the overall sex difference, and that between men and women in the sciences, were significant.) Thirty-eight percent of the respondents said their current relationship was affecting their plans; 41% of the women in science gave this response, compared to 38% of the women in other fields and 34% of the men.

In response to the first question, 151 respondents--116 women and 35 men--supplied some comment about the impact of their family concerns on their career plans. In general, the overall sex differences were much more striking than differences between men and women within the sciences or within other fields. Two sorts of responses appeared most frequently, each given by 38% of those responding. The first type of response included a variety of general concerns--about becoming a parent, trying to "do it all," having time for everything, etc., and about anticipated problems in meshing two careers, involving potential problems of location, job selection, etc. Overall, 40% of the women and 31% of the men made such comments. However, women were more likely to voice general concerns about becoming a parent, playing both roles, etc. (16%, vs. 3% of the

men), and men were more likely to phrase their concerns in terms of location, which job to take, etc. (20%, vs. 5% of the women). In other words, while men might recognize that maintaining a relationship could affect their decisions about where to locate, they were not apt to think in terms of the impact of parenthood on their careers. The second type of response included various restrictions that the respondent would place upon his or her career; these responses were given more frequently by women than by men (41% vs. 29%). The sorts of restrictions mentioned included unwillingness to travel a great deal, the need for a flexible schedule, the need to select an area or specialty that would allow for raising a family, and the comment that the respondent did not intend to work during the early years of parenthood. Specifically, 11% of the women--and none of the men--said that they did not plan to work while their children were young.

The third most common type of response concerned problems that the respondent's chosen field would present--problems such as travel requirements, or long hours and inflexible schedules, the total or heavy commitment required, long years of preparation, location, etc. Such responses were given by 25% of the respondents. These responses were given more frequently by men than by women--43% of the men, compared to 19% of the women. More women referred positively to characteristics of their chosen field which would permit them to combine their family and work more easily; 14% of the women made such comments, compared to 3% of the men. Five percent of the women, but no men, made negative references to a field they had rejected (for example, "I didn't think I could be an MD and a mother at the same time"). Five percent of the women also commented that they did not want to commit themselves to long years of training or preparation before launching a career. The women's comments thus imply that they have had family considerations in mind in selecting a field, or area of specialty within a field, whereas the men simply recognized that their chosen field may present problems, from the standpoint of having a family, or that their initial selection of a particular job or school may be influenced by the desire to coordinate decisions with a partner. Ten respondents--nine women and one man--mentioned restrictions they would place on their family roles, such as not letting such considerations impede or destroy their career, or delaying having children until their career was well launched.

In response to the question concerning whether a current relationship was affecting plans for the future, 115 women and 42 men answered in the affirmative. Two-thirds of those responding to the open-ended probe--71% of the women, and 55% of the men--mentioned ways in which their relationship might affect where they located, in graduate school or on the job. That is, they commented that they might go to where the partner was, or would be, or that they would stay in the area to be near the partner, or that they and their partner were looking for jobs or schools in the same area, or more generally that the relationship might affect which job or school they chose. One-fourth of the women, but only seven percent of the men, specifically said that they would stay in the area where their partner was, or go to the area where the partner would be located.

The other major category of responses to the second question concerned issues of timing, or the need to be flexible in pursuing one's career, in order to coordinate developments with events related to the partner's career, or to make it possible to pursue family goals at the same time. Thirty-one percent of the women, and 21% of the men, gave such responses.

Two types of responses occurred differentially among the women: Women in science were more likely than other women to mention positive characteristics of the area they had chosen, which would make it easier to have a family (21% vs. 9%), and they were more likely to mention restrictions that they would impose on their careers, in order to accommodate their family roles (49% vs. 35%). (To what extent these differences reflect

actual differences between careers in science and in other fields, and to what extent they reflect differences in the clarity and specificity with which the women envision their future careers, is difficult to say. Since more of the women in science described themselves as having a significant other, they may have been more likely to be thinking about these issues.) Among the men, a smaller proportion of those in science than of other men said that they would choose a location in order to be near their partner.

A final question on this topic asked respondents, when they thought about the future, how they envisioned a partner's level of career commitment, compared to their own--that is, whether they assumed the partner would be less serious, equally serious, or more serious about a career. Overall, men and women differed significantly in their responses, as did men and women in the sciences. Overall, 80% of the respondents indicated that they assumed their partner would be equally serious about a career. However, 20% of the men, but only two percent of the women, said that they assumed their partner would be less serious about a career; 14% of the women, but only four percent of the men, assumed that their partner would be more serious about a career. Among the women, there was little difference by field in their views. Among the men, those in science were more likely than those in other fields to assume that their partner would be less serious than themselves about a career (24% vs. 14%), and they were less likely than other men to assume that their partner would be equally serious about a career (69%, vs. 78% of other men). In other words, a larger proportion of the men planning careers in science appeared to be expecting a somewhat traditional relationship--in which the woman's career is less important than the man's--than was true for any of the other groups of respondents. Women entering scientific fields may thus be slightly more likely than other women to encounter male colleagues of their own generation whose attitudes are less than fully supportive of women's efforts to have both careers and families.

Attitudes About Science and Careers

Several sets of items were designed to tap respondents' attitudes and values, first about career issues generally and then more specifically about science and careers in science.

Importance of Various Job Characteristics

The first set of items presented 20 job characteristics reflecting personal values and goals which might influence respondents' career choices or their attitudes about their future work. Respondents were asked to rate how important each characteristic was to them, using a five-point scale (1=Not at all important; 5=Very important). Table 6 gives the percentage of each group rating an item as either 4 or 5. Again, respondents overwhelmingly indicated the importance of enjoying what they did: 97% gave high ratings to "Opportunity to engage in tasks you enjoy doing." Five other characteristics were given high ratings by at least 70% of the respondents: Having the opportunity to take responsibility (91%), having a great deal of intellectual challenge (88%), being able to take the initiative (84%), having the opportunity to be helpful to people (75%), and having the opportunity to be creative (71%).

Students in science were more likely than those in other fields to assign importance to job availability, to having the opportunity to solve problems, and to creating new knowledge. Science students were less likely than other students to assign importance to working to change society, to working independently, and to avoiding lengthy graduate training. Among the students in science, men were more likely than women to assign

importance to being creative (83% vs. 63%), to taking the initiative (90% vs. 78%), and to shaping important programs or policies (61% vs. 53%). However, women in science were just as likely as the men to give importance to taking responsibility. Men in science were less likely than women in science to assign high importance to having a flexible schedule (37% vs. 54%), and to winning recognition for their achievements (39% vs. 50%). These data suggest that undergraduate women in science are less likely than their male classmates to be thinking in terms of assuming leadership roles, of exerting influence or power, but they are concerned with achieving responsibilities and recognition commensurate with their abilities and contributions. And they are more aware of the need to have schedules that might make parental and career roles more compatible.

Endorsement of Criticisms of Science Classes

Another set of items asked respondents to indicate how strongly they agreed or disagreed with seven criticisms which are frequently heard about science or math classes at U-M. Respondents used a five-point scale (1=Strongly agree; 5=Strongly disagree). Table 7 gives the percentage of each group responding either 1 or 2 to each item--in other words, who indicated agreement with the complaint expressed in the item. Overall, the highest level of agreement was obtained for the complaint tapping difficulties in communication between students and TA's: 72% of the respondents indicated agreement, with little variation among the groups. A fourth of the respondents indicated strong agreement with the item. (It should be noted that, given the wording of the item, respondents may have had in mind not only the language difficulties of foreign TA's, but also the lack of teaching experience of TA's, compared to professors. However, there were frequent comments that made specific reference to TA's who were not proficient in English.)

Science students were much more likely than other students to agree that science courses were more difficult than other courses, and that science majors have difficulty fitting desired electives into their schedule. Nevertheless, 40% of the non-science students agreed with the opinion that science courses were more difficult than other courses. More than half of the women in science agreed with the view that science courses take too much time--56%, compared to 43-47% of the other groups.

Forty-five percent of the students agreed with the complaint that students in science classes are too aggressive and competitive, with little difference among the groups; 30% of the respondents indicated disagreement with this view. (Twenty-seven percent indicated strong agreement with this view, including 31% of the men in science and 33% of the women in science.) Thus, agreement with this complaint is apparently not limited to women, or to those who have chosen fields other than science.

Nearly 40% of the students agreed with the view that science and math courses are not concerned with values. However, this item elicited the most even distribution of responses: 16% percent indicated strong agreement, 13% indicated strong disagreement, with the other responses fairly evenly distributed across the other scale points. Science students, both male and female, were more likely than other students to disagree with the item.

Self-descriptions of Science and Non-Science Majors

Science majors and non-science majors were given separate sets of statements and asked to indicate how well each statement described them, using a five-point scale (1=Does not describe me at all; 5=describes me very well). For the students in science, section A of

Table 8 gives the percentage who rated each item as 4 or 5--that is, who felt that the item was moderately or very descriptive of them.

Men and women in science were basically similar in their levels of agreement with most of the descriptive statements. Three points of difference might be noted: Women showed slightly less confidence about their talent for scientific work; women were more likely to agree that their parents had encouraged them to go into science (and just as likely to say the same about their teachers); and, if we look only at the percentage giving a rating of 5, more women endorsed as self-descriptive the view that a scientific education will be useful to them in getting a good job.

Responses for women and men in the humanities and social sciences are shown in section B of Table 8; again, the entries in the table represent the percentage indicating that the statement described them fairly or very well. A third of the women, compared to only 22% of the men, indicated that they had never considered going into science. However, relatively few respondents indicated that they had never liked science--14% of the women, and eight percent of the men; indeed, nearly three-fourths of them said that this statement did not describe them (i.e., responded with a rating of 1 or 2). A majority of the non-science respondents endorsed the statement that they had done well in science, but that other subjects interested them more (63% of the women, and 70% of the men).

Respondents strongly rejected the suggestion that their parents had not encouraged them to go into science--nearly 85% marked this statement at the "does not describe me at all" end of the scale. The suggestion that teachers had not encouraged them was also rejected, although not quite so sweepingly: five percent of the women (and only two percent of the men) felt that this statement described them, while 84% of the women, and 94% of the men, said that the statement was not very descriptive of them; 70% of the women, and 76% of the men, said that the statement did not describe them at all (i.e., rated it 1 on the scale).

A higher proportion of women than men endorsed as self-descriptive the statement that they did not have the talent for scientific work (24% vs. 14%). However, women were more likely than men to reject as self-descriptive the view that a science major takes too much time and effort: 56% of the women, compared to 41% of the men, rated this item as 1 or 2 on the scale. Possibly the women wished to indicate that their choice of a non-science field did not stem from an unwillingness to work hard.

Ratings of Problems for Women in Science

A fourth set of items presented respondents with 11 factors which might tend to discourage women from pursuing careers in science. For each factor, respondents were asked, first, to indicate whether they felt that it was "no problem," "a minor problem," or "a serious problem" for women; secondly, they were asked to indicate (yes or no) whether the factor represented a serious problem for them, personally. Table 9 gives, for each factor, the percentage of each group who felt that the factor was a serious problem for women, and the percentage who indicated that it was a serious problem for them, personally.

Students in science were significantly more likely to see possible conflicts between career and family responsibilities as a serious problem for women. Women in science were more likely than other women to regard such conflicts as a serious problem for women generally (58% vs. 35%), and for themselves personally (37% vs. 21%). These differences are not explained by differences in the percentage of women in each group who are engaged or have significant others: if we look only at the women who described

themselves as single and "unattached," 62% of the women in science, but only 33% of the women in other fields, felt that this issue was a serious problem for women; 39% of the unattached women in science, compared to 21% of the women in other fields, indicated that this issue was a serious problem for them personally.

Lack of encouragement from teachers or counselors was seen as a serious problem for women by a third of the respondents, with 19% of the women indicating that this was a serious problem for them. Interestingly, lack of encouragement from family or friends was more likely to be seen as a problem for women by men than by women. While 21% of the women perceived this factor as a serious problem for women, only 4% of the women in science, and 7% of the women in other fields, indicated that this was a serious problem for them, personally.

Lack of confidence that they could handle the work was rated as a serious problem for women in science most frequently by women in science--34%, compared to 26% of other women; 17% of the women said that this was a serious problem for them. Lack of information about careers in scientific fields was seen as a serious problem for women by a fourth of the women, with roughly a fifth of them saying that it was a serious problem for them. Lack of contact with women in scientific fields was even more likely to be seen as a serious problem for women: 41% gave this response, including 49% of the women in science. A third of the women in science indicated that this was a serious problem for them.

The aggressive, competitive attitudes of students in science classes was seen as a serious problem for women by 35% of the women, and by roughly a fifth of the men. Similar percentages of the women (32% of those in science and 38% of those in other fields) indicated that this factor was a serious problem for them. Interestingly, the view that scientists are cold and impersonal, which was seen as a serious problem for women by 16% of the respondents, and reported to be a personal problem by 12%, was as likely to be regarded as a problem by men as by women.

The fear that women in science are seen as unfeminine was judged to be a problem for women by 15% of the women, but was seen as a personal problem by very few--eight percent of the women in science, and two percent of other women, felt that this factor was a problem for them. The necessity for long years of preparation was seen as a problem for women by 10-12% of the women; women in fields other than science were slightly more likely than women in science to say that this factor was a problem for them.

Discriminatory attitudes toward women in science was seen as a serious problem for women by 37% of the respondents, with men in science slightly less likely to give this response. Eighteen percent of the women in science, and 15% of the women in other fields, reported that this was a serious problem for them.

Do ratings of these possible problems for women in science help us to explain attrition from science majors among women? Among the women who indicated that they were interested in science when they first enrolled at Michigan, when we compared those women who ultimately chose a non-science field of concentration with those who selected science majors, one factor stood out as having a differential impact: 50% of the women who chose non-science majors, compared to only 36% of those who chose science majors, said that the aggressive, competitive attitudes of students in science classes was a serious problem for women; 45% of the first group, compared to 34% of the second, said that it was a serious problem for them personally. When reacting to the set of frequent criticisms of science classes, the women who did not pursue their interest in science were significantly more likely than those who did to agree strongly with the complaint that

students in science classes were too aggressive and competitive: 36% indicated strong agreement, compared to 16% of the women who selected science majors. These attitudinal measures thus corroborate the data reported earlier with respect to distinctive features of classes which had had a discouraging influence on respondents.

The women who did not pursue their initial interest in science also appeared to be somewhat more concerned than those who did about committing themselves to long years of graduate training, on the two items which tapped this factor. And they appeared to attach slightly less importance to earning a high income or to job availability, and to give slightly more importance to being able to help people. They thus appear to be expressing attitudes which might be seen as slightly more traditional for women.

When we examine attrition among the men, we find several parallels to the differences between women who persisted in and those who abandoned their initial interest in science. Among the men, significant differences were found for three items: men who did not pursue their interest in science were strikingly less apt to attach importance to earning a high income (22%, compared to 57% of the men who stayed in science, rated this characteristic as 4 or 5); they were markedly more interested in having a flexible schedule (61%, vs. 36% of men in science, rated this factor as 4 or 5); and they were markedly more likely to agree that science and math courses were not concerned with values (65%, compared to 35% of the men who stayed in science). They were also more concerned about the prospect of long years of training--47% rated this factor as a serious problem for themselves, compared to 7% of the men who pursued their initial interest in science. Men who did not pursue their initial interest in science were, like their female counterparts, more apt to agree with the view that students in science courses were too aggressive and competitive--65%, compared to 48% of the men who stayed in science, indicated strong or moderate agreement with this criticism. In their responses to the factors suggested as posing problems for women in science, men who did not pursue their initial interest in science appeared to be somewhat more likely than the men who stayed in science to see a variety of issues as at least a minor problem for women; that is, they were less likely than the men in science to say that a given issue was no problem for women. Thus, men who had an initial interest in science, but who did not choose a field of concentration in science, appeared to share some of the concerns expressed by women about science and scientific careers.

Discriminatory Experiences in U-M Classes

Following the set of items about problems that might discourage women from pursuing careers in science, respondents were asked directly if they had ever personally experienced in a science or math class either an advantage or disadvantage that they attributed to their being a man or a woman. Overall, 19% of the respondents said yes: 36% of the women in science, and 14% of the women in other fields, compared to 17% of the men in science, and four percent of the men in other fields. When asked to describe the experience they had in mind, six percent of the respondents cited experiences where they felt women had an advantage, because they were women; 20% of the respondents described experiences in which women were at a disadvantage, because they were women. (Some respondents gave instances of both advantage and disadvantage.) Among the women in science, 14% gave instances of advantage, and 24% described examples of disadvantage. Among the men in science, seven percent cited instances of women having an advantage, and 11% referred to examples of women being at a disadvantage.

If we restrict our attention to the 78 respondents who gave examples of discriminatory behavior, it is interesting to note that women in non-science fields primarily gave instances of disadvantage with very few references to possible advantages, whereas

41% of the women in science gave examples of women having an advantage, with 69% citing negative experiences. While there were only 12 men in science who gave examples of discriminatory treatment, the percentage citing instances of women having an advantage and of women being at a disadvantage were essentially the same as among the women in science.

Where the differential treatment of women was described as an advantage to them, professors or teachers were said to help women more, to require less from them, to be more lenient in grading them, or simply to notice or pay attention to women more readily (because there were so few of them). Where such treatment was described as a disadvantage, it was said that professors or others put women down, did not take them seriously, did not respect their ability, ignored them or patronized them, assumed that women were less able intellectually than men, or that they had no talent for science or math, or did not belong in science. (A few women referred to having encountered the stereotype that attractive women--particularly if they were small and blond--could not be very bright.) In a few cases such attitudes were attributed to classmates or to men in general, but the majority of the references appeared to be to the professor of the class, with a smaller number of mentions specifically referring to teaching assistants. There were a few references to issues of sexual attraction--either as an advantage, because attractive women could win favors or extra help more easily, or as a disadvantage, with reference to unwelcome attention from male TA's, etc. But clearly the great majority of complaints concerned the general attitudinal factors mentioned above. Apparently students still encounter faculty members who are not accustomed to having women as students or colleagues, and who hold stereotypic views about women's interests and abilities. Such attitudes may not necessarily present serious problems for the student--several women commented that they enjoyed proving that they could do well--but for others with less confidence or less certainty about long-term goals, disparaging attitudes in the classroom surely contribute to the creation of an unpleasant atmosphere for women.

Evaluation of Academic Counseling

In the final section of the questionnaire, respondents were asked to comment on the adequacy or helpfulness of the academic counseling they had received at Michigan. For the most part, their responses were negative in tone. A fifth of the respondents, with little difference among the groups, said that the counseling was helpful, either generally or in certain ways, or adequate for what they needed from it. Three-fifths, however, said that it was inadequate or not helpful. (A fifth of them expressed their reaction in strongly negative terms--"totally inadequate," "it stinks," "What counseling?", etc.) Fifteen percent indicated that they had made little or no use of the services available, or did not need them. Men in science were somewhat less likely to respond with a negative evaluation--51% did so, compared to at least 60% of each of the other groups.

More than a fourth (27%) of the respondents cited specific ways in which they felt the counseling was inadequate. They reported that it was too bureaucratic and impersonal, that the counselors were ill-informed and gave out misinformation, that they did not encourage students to try different options or fields, that they made inappropriate judgments about students (without really knowing them), that they only knew what was in the catalogue, or just agreed with whatever the student wanted to do. Women, particularly those in the humanities and social sciences, were more likely than men to say that the counseling process was too impersonal--that counselors were not interested in looking at the student as a person, or in helping them devise individual courses of study.

Respondents were then asked what issues or questions they would like to have addressed, in counseling or in workshops or other programs. Thirty percent of the

respondents wanted more information about careers, with women more likely to express this need than men--34% vs. 23%. Respondents wanted to know more about career options and alternatives, in their own field or in other fields; what was required for different fields, how to get experience to see what a given field would be like, the payoffs and pressures in different fields (including issues of discrimination, for women). Eighteen percent of the women in science, and nine percent of the women in other fields, specifically expressed a desire for more information about women in various career fields.

Thirty percent again suggested ways in which the counseling system could be improved, or gave further examples of its deficiencies, with little difference among the groups. A smaller number of respondents mentioned various issues related to personal development--ways in which they felt inadequate or uncertain--with women more likely to give such responses than men (14% vs. 7%).

Finally, respondents were asked about the biggest problems they faced, in making decisions about future careers and/or further education. Overall, 28% responded in terms of the need to make basic choices about what they wanted to do--what field or type of career they would enjoy pursuing, or would be good at; deciding how deeply they were committed to their present field; where they wanted to be in 10 years; how their decisions might limit or enhance their options later on; how to choose among competing interests. A fifth of the respondents mentioned immediate concerns about financial issues--whether they could afford to go to graduate school, or how to finance further study; how to pay off debts, and whether to incur more debt. A fifth expressed concerns about immediate employment concerns--how to select and obtain the right or best position. Thirteen percent mentioned concerns related to graduate education--issues related to selecting and gaining admission to appropriate graduate programs, or doubts about whether they wished to commit themselves to many more years of schooling.

Fifteen percent of the respondents referred to concerns about combining careers and family responsibilities, with 30% of the women in science and 16% of the women in other fields expressing such concerns (but almost none of the men). A fourth of the women in science, and 13% of the other women, referred to the difficulties of having families while pursuing careers; a smaller number referred to concerns about coordinating their career interests with those of a partner.

Discussion and Conclusions

Early research into the origins and development of scientific talent suggested that interest in science tends to develop early among those who achieve eminence in scientific careers (Roe and Siegelman, 1964). However, a recent study of thousands of students, who were followed from their second year in high school to their second year in college, demonstrates that nationwide there is considerable movement into the sciences even in the first years of college (Lee, 1987a). The evidence presented in this report that there is essentially no such movement out of other fields into science at the University of Michigan is therefore troubling, since it suggests that students whose pre-college experiences are not conducive to developing an interest in science are unlikely to do so once they have enrolled at U-M. This is particularly relevant for women and minorities, because, for various socio-cultural reasons, women are less likely than white males to take advanced math courses in high school, and black students are less likely than white students to be tracked into college-preparatory courses. Both of these factors place students at a disadvantage with respect to pursuing science majors in college. Efforts to increase the numbers of women and Blacks in science at U-M are constrained by the failure to attract into scientific fields

any of those who initially expressed an interest in other fields, and by an overdependence on advanced preparation in high school as the basis for success in introductory science and math courses in college.

Nationwide, among students who indicate an interest in science when they first enroll in college, women are less likely than men to select a major in the sciences (Lee, 1987a; Ware, Steckler, and Leserman, 1985; Oggins, Inglehart, and Brown, 1988). However, among those students who select a science major, women are more likely than men to complete an undergraduate degree in science (OTA, 1988). It would thus appear that only those women who are surest of their interest in science, or of their talent for scientific work, or of their need for scientific training, are apt to choose a science major; in weighing the attractions of various fields, women are more likely than men to be deterred by the difficulties they perceive to exist in the pursuit of science.

The difficulties women face in the study of science at U-M and other large universities appear to fall into several categories: less advanced high school preparation in math, and less confidence in the adequacy of their academic background for studying science; a dislike for the aggressive, competitive atmosphere in introductory science and math classes, and a general lack of encouraging or enjoyable experiences in those classes, along with a greater recognition of their talents in other courses; a lack of female role models in science; differential aspirations of parents for sons and daughters; the differential impact of having or not having clear career goals; and concerns about combining family and career roles. We will comment on each of these factors below, incorporating our findings with those of other recent studies which have analyzed gender-related influences affecting achievement or attrition in science in large university settings.

(1) Women take fewer math and science courses in high school than men (Lee, 1987b), and they consistently score 40-50 points lower on the quantitative portion of the SAT (OTA,1988); moreover, high grades and achievement in math are significantly related to the choice of a science major (Lee, 1987b). (In the current study, women science majors had significantly higher SAT quantitative scores than women in other fields, but significantly lower scores than the men in science.) The reasons why women show less interest in math have not been very clear. Eccles has presented a theoretical framework for explaining the choices women make, based on their expectations of success or failure in different fields, their attributions about the causes of such success or failure, and the subjective value of different tasks in light of their interests and goals, and demonstrated how each of these factors is affected by the typical sex-role socialization experienced by women (Eccles, 1987; Eccles, Adler, and Meece, 1984). Our finding that, for women, having a mother in science was positively related to taking advanced placement math courses and tests suggests that part of the problem may reflect the view of the world and women's roles that young girls unconsciously absorb as they grow up: where the mother's identity legitimizes such "masculine" interests, daughters have a wider range of behavior open to them. In any case, it may be that too much emphasis is placed on the relevance of the quantitative SAT scores: A recent comparison of men and women who were interested in medical school when they first enrolled at U-M revealed that the women's ultimate decisions to go to medical school were not significantly related to their quantitative SAT scores, and that, despite having lower quantitative scores than the men, these women did equally well in natural science courses in college (Oggins, Inglehart, and Brown, 1988).

(2) The importance of the emotional valence of the classroom--of the affective aspect of learning--is reported in several studies. Among our respondents, the lack of encouraging experiences in introductory science or math courses was more telling than the occurrence of discouraging experiences, as a factor associated with attrition from an interest in science. Similarly, Ware, Steckler, and Leserman (1985) reported that students who

found a science course to be the most enjoyable course in their first year in college were more likely to persist in science than those who named a non-science course as the most enjoyable. Lee and Ware (1985) found that nationwide, women majoring in science tend to be dissatisfied with the academic aspects of their college experience. Lyons-Lepke (1986) reported that defectors tended to be discouraged by the general atmosphere in science and math classes, and that they found classroom peers, mainly male, to be competitive and unfriendly; both persisters and defectors felt that the introductory classes in math and science were too large and were poorly taught.

Inglehart and Brown (1987) argue for the importance of affective factors, including values, as influences on academic achievement; they demonstrate that men and women in medical school do not differ in terms of prior achievement and career expectations, but do differ in terms of their value priorities and their assessment of the atmosphere in their program. In related studies, this team of investigators found that women's evaluations of the environment as being competitive was detrimental to their achievement (Inglehart, Nyquist, Brown, and Moore, 1987), but also that women's person-related values predicted significantly to their performance in the clinical setting, where women received higher ratings than did the men (Oggins, Inglehart, Brown, and Moore, 1988). On the basis of several studies, Eccles concluded that "girls develop more positive attitudes toward math in classrooms characterized by low levels of competition among the students, high levels of cooperative learning or an individualistic learning structure, and high levels of teacher communication of both the intrinsic value of math and the link between math and various interesting occupations"(Eccles, 1986, p. 19). Ware, Steckler, and Leserman (1985) found that freshman-year science grades were not a significant predictor of women's choice of a science major (although they were for men); among women, having both a strong need for power and a desire for positive affiliations with others was related to the choice of a science major--in other words, their value structure included what might be considered a typical feminine value.

In the present study, among women who said that they had initially been interested in science, those who ultimately chose majors in other fields expressed significantly greater agreement with the view that students in science and math classes are too aggressive and competitive. Disliking the classroom atmosphere was one of the more frequent complaints among women who named the introductory chemistry and calculus courses at U-M as having had a discouraging effect on their interest in science. There would appear to be considerable evidence accumulating, then, that these affective factors are a significant influence on women, and must be taken into account in efforts to increase the participation of women in science. (Attention to these influences represents a fairly new wave of research; in the words of one team of investigators, "For whatever reason, researchers have tended to neglect what common sense suggests is a very powerful factor, namely, how students feel about the first science courses they take in college" [Lee and Ware, 1985, p. 3]).

(3) Women in science attached considerable importance to the lack of contact with women in scientific fields, and to a lack of information about careers in scientific fields. Oggins, Inglehart, and Brown (1988) found that women who decided to go to medical school reported having a significantly higher level of "informational support" for their decision--such as knowing an adult figure in the field who provided an example and could give information--than did the women who decided against going to medical school. Thus, the presence or absence of appropriate role models remains an important factor influencing the decisions of women with respect to pursuing careers in science.

It is particularly discouraging to note the absence of women role models in the classroom setting, nationwide and at the University of Michigan. At this institution, for

example, currently only 8% of full professors in the College of Literature, Science, and the Arts are female; the figure would be smaller if one looked only at the sciences. Visible role models in the sciences are important in helping underrepresented groups such as women and minorities to visualize the attainment of professional and personal goals.

(4) Parental influences on the decision to study science have been reported in several studies (Meisel, 1983; Lee and Ware, 1985; Ware, Steckler, and Leserman, 1985; Lyons-Lepke, 1986). Meisel found that women who persisted in science after their first year of college (at The University of Michigan) were more likely to have mothers working in science-related fields, a finding replicated in the present study. Ware, Steckler, and Leserman found that having highly educated parents was associated with women's choice of a science major. Lee and Ware reported that female science majors were more likely to have mothers working in relatively prestigious occupations. Lyons-Lepke concluded that the most important factor for a woman's persistence in science is having a father who is encouraging, who holds a scientific position, and with whom the daughter can identify. She asserts that the mother has little influence on a daughter's decision to persist in or defect from an interest in science. However, given her relatively small sample (25 persisters and 25 defectors), her study may have been less likely to include women whose mothers are in scientific occupations; furthermore, the relationship reported in the present study does not reflect an influence reported by the daughter, but rather an empirical observation of a statistical relationship between mother's occupation and daughter's choice of field. Our findings do accord with her suggestion that being able to identify with the father is important: women in science were more likely than other women to say that they resembled their father in terms of interests and abilities.

Parents can also have an influence aside from the specific modeling or approval of an interest in science. Our data suggest that parents, particularly mothers, place more emphasis on being happy for daughters than for sons. This may result in their placing less emphasis for their daughters on the attainment of high-status career goals. One investigation of the college experience, for example, suggests that women majoring in subjects such as English may have highly supportive parents who do not encourage aspirations for high-status occupations among their daughters (Weidman, 1979). Such parental stress on achieving a happy life may well increase the doubts felt by women who fear that pursuing a career in science might interfere with the achievement of other important goals. Other relevant parental patterns of influence have been summarized by Eccles (1987), including the belief that sons' math achievement is more reflective of ability, while daughters' math achievement is more reflective of effort; that English is more important for daughters and math is more important for sons; and that sons have greater ability in math, while daughters have greater ability in English.

(5) In our study students who chose science majors placed more emphasis than other students on the importance of their field of study as preparation for a career. This appears to be particularly true for women in science. The importance of having a clear career goal as a motivating factor for remaining in science is touched on by several of these authors (Lyons-Lepke, 1986; Inglehart, Markus, and Brown, 1987). Having such a goal apparently helps to counterbalance the negative impact of other factors, such as the competitive classroom atmosphere, or uncertainty about one's mathematical abilities. In the absence of such a goal, the fact that women's abilities are more likely to be recognized and rewarded in non-science fields increases the likelihood that they will choose non-science fields as majors.

(6) Women in science in our study appeared to be more concerned about combining career and family roles and responsibilities than were women going into other high-status and high-pressure fields, such as business and law. Similarly, Lyons-Lepke (1986)

reports considerable concern about this factor, among both her persisters and defectors. Perhaps this reflects the more specific career orientation of women in science described above. Possibly women in science are subjected to more dire warnings about the difficulties of pursuing a career in science and having a family at the same time. But it may also be that women who go into science hold more traditional sex-role attitudes than women who enter other high-status occupations. In a previous survey of U-M graduates with recent graduate or professional degrees, Manis (1983) noted that women who had earned degrees in engineering appeared to be more traditional in their views about marriage and family roles than women entering other formerly male-dominated fields. Blackman (1983) reported that women in mathematics held more traditional views about sex roles. If such views are indeed more typical of women in science, one would expect them to foresee more problems with respect to career/family conflicts than other women might envision. One should not assume that their choice of a "nontraditional" field of study and work reflects nontraditional attitudes about marriage and family roles.

Recommendations

Serious attempts to increase the number of women in science, and to retain a larger proportion of those who express an initial interest, will need to take account of these factors which create problems for women who are or who might be interested in the sciences. The following recommendations suggest several approaches whose implementation should lead to more positive experiences for women students at The University of Michigan:

1. Efforts should be undertaken to develop new courses or to incorporate within existing courses more cooperative and interactive modes of learning. Intense emphasis on individual competition for grades should not be regarded as the only viable approach to learning scientific concepts. In any case, more attention should be given to providing the highest quality of instruction in introductory science and math classes. Many students have had negative experiences in science or math classes in high school; if their first experiences in college in such courses are also negative, they are unlikely to persevere in the pursuit of scientific careers.

2. Courses might also be developed that link scientific knowledge more closely to important societal issues, thus tapping what may be an important source of motivation and interest for many students.[4] Likewise, the incorporation into courses of material that acknowledges the contribution of women and minorities to the sciences can also contribute to the aspiring student's sense of identity and belonging.

3. Efforts to recruit more women faculty and researchers in the sciences should be strengthened. Undergraduate U-M women see very few role models in science or engineering with whom they can readily identify. The same situation exists at the graduate level.

4. Increased attention should be paid to offering relevant experience outside the classroom for undergraduates, with particular emphasis on women and minority students. Internships or other forms of participation in research projects, with associated mentoring, offer students another route to discovering an affinity for scientific inquiry and routine, or to developing an interest in a particular problem, or to becoming acquainted with positive adult role models. At present, students in science are less likely than students in other fields to cite relevant work or volunteer experience as an important influence on their choice of field.

5. Attention should be given not only to developing more effective ways of teaching math, but also to the question of whether too much emphasis is put on high

proficiency in mathematics as a basis for pursuing any scientific career. Women who encounter more difficulty in math courses than in other courses may come to doubt their abilities, and/or assume that they would not enjoy scientific work, and hence may too readily abandon any thought of a career in science, when in fact they would be capable of mastering the actual level of math required in many scientific curricula and occupations, and might be interested in other aspects of such careers.

6. Correspondingly, attention might be given to adapting courses and grading procedures to place greater emphasis on writing skills. Being able to communicate one's knowledge to others is as vital in science as in other fields; yet science courses are rarely perceived as drawing on verbal skills. Allowing students to demonstrate their understanding in other modes, as well as in abstract quantitative formulas, might make the study of science more congenial for women.

Notes

1. This project was initiated by the Women in Science Program at the Center for Continuing Education of Women at The University of Michigan. It was planned by a committee which included Dr.Cinda-Sue Davis, Director of the Women in Science Program, and Suzanne Tainter, a Program Associate with the Women in Science Program; Dr. Barbara Sloat, lecturer in the Residential College at The University of Michigan and former director of the Women in Science Program; Karen Hankins and Mona Mansour, undergraduate students at Michigan; Dr. Nancy Thomas, Associate Director of the Michigan Program in Child Development and Social Policy; and Jean Manis, Research Investigator at CEW.

2. Similar questionnaires were administered to 121 senior women at Mt. Holyoke College. These data have not yet been analyzed.

3. One major influence of family or other background factors may be in determining what fields are never even considered--a process the student may be less aware of, when describing influences on his or her choice of field.

4. The Residential College course "Science and Societal Issues: The Immune System," developed and taught by Barbara Sloat, provides one model for the effective incorporation of societal issues into a science course.

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Table 1

Advanced Placement Courses, Advanced Placement Tests, and Exemptions from UM Courses*

	Total	Women in Humanities and Social Sciences	Women in Science, Math, or Engineering	Men in Humanities and Social Sciences	Men in Science, Math, or Engineering
	(420)	(186)	(111)	(52)	(71)
Advance Placement Courses					
Humanities	41.4	38.2	43.2	38.5	49.3
Foreign Languages	11.9	14.0	15.3	1.9	8.5
Mathematics	36.0	27.4	43.2	36.5	46.5
Sciences	30.7	21.5	41.4	26.9	40.8
Advanced Placement Tests					
Humanities	34.8	29.0	39.6	30.8	45.1
Foreign Languages	9.8	10.81	16.2	1.9	2.8
Mathematics	21.4	10.8	28.8	19.2	39.4
Sciences	19.3	9.7	32.4	17.3	25.4
Exempted from UM Courses					
Humanities	22.1	18.8	30.6	17.3	21.1
Foreign Languages	11.0	12.9	14.4	7.7	2.8
Mathematics	18.1	8.6	22.5	17.3	36.6
Sciences	16.2	9.1	27.0	7.7	23.9

*Entries are percentages of each group who had taken at least one advanced placement course or advanced placement test or had been exempted from at least one UM course in each area.

Table 2

Factors Affecting Choice of Field of Study at First Enrollment, by Sex and Field
(% rating factor as 4 or 5)*

	Total (420)	Women in Humanities and Social Sciences (186)	Women in Science, Math, or Engineering (111)	Men in Humanities and Social Sciences (52)	Men in Science, Math, or Engineering (71)
Family Member	50.9	45.6	64.8	34.7	54.9
Teacher or counselor	24.9	22.3	33.3	11.5	28.1
Other adult	15.9	17.2	14.4	7.7	21.2
Friends or fellow student	27.6	27.8	28.8	19.2	31.4
High school course(s)	59.5	51.9	66.6	53.9	71.8
Work experience	20.2	24.6	13.5	19.2	19.7
Volunteer or travel experience	22.0	27.1	19.8	19.6	14.1
Your own talent in the field	79.4	81.0	76.5	72.6	84.5
Strong background in the field	51.1	41.9	57.3	44.2	70.4
Personal enjoyment, interest	88.7	90.1	88.2	88.4	85.9
Importance of field as preparation for intended profession or career	68.4	66.1	75.5	53.0	74.6

*Scale: 1= Not at all important ; 5=very important

Table 2A
Mean Ratings of Importance of Factors Influencing Initial Field Preference
by Sex and Current Field of Concentration

		Overall Mean (420)	Women in Humanities and Social Sciences (186)	Women in Science, Math, or Engineering (111)	Men in Humanities and Natural Sciences (52)	Men in Science, Math, or Engineering (71)
***	Family member	3.3238	3.1685	3.6937	2.9615	3.4366
	Teacher or counselor	2.5119	2.4293	2.7207	2.3269	2.5775
	Other adult	2.0624	2.0552	2.0270	1.8654	2.3099
	Friends or fellow students	2.5837	2.5956	2.6667	2.3269	2.6143
**	High school course(s)	3.5012	3.2951	3.7207	3.4038	3.7606
	Work experiences	2.2458	2.3825	2.0360	2.2115	2.2535
*	Volunteer or travel experience	2.2043	2.4144	2.1532	2.0588	1.8873
	Your own talent in the field	4.0621	4.0435	4.0360	3.9020	4.2817
***	Strong background in the field	3.3246	3.0652	3.4455	3.2115	3.8873
	Personal enjoyment, interest	4.4317	4.4835	4.3909	4.3654	4.3944
**	Importance of field as preparation for intended profession or career	3.8633	3.7978	4.1000	3.4118	3.9859

Note: Probabilities obtained in univariate analyses of variance.

* = P<.05
** = P<.01
***= P<.001

Table 2B

Mean Ratings of Importance of Factors Influencing Initial Field Preference
by Current Field of Concentration

		Overall Mean (420)	Humanities and Social Science Students (238)	Science, Math and Engineering Students (182)
**	Family Member	3.3238	3.1229	3.5934
*	Teacher or counselor	2.5119	2.4068	2.6648
	Other adult	2.0624	2.0129	2.1374
	Friends or fellow students	2.5837	2.5362	2.6464
***	High school course(s)	3.5012	3.3191	3.7363
	Work experience	2.2458	2.3447	2.1209
*	Volunteer or travel experience	2.2043	2.3362	2.0495
	Your own talent in the field	4.0621	4.0128	4.1319
***	Strong background in the field	3.3246	3.0975	3.6188
	Personal enjoyment, interest	4.4317	4.4573	4.3923
**	Importance of field as preparation for intended profession or career	3.8633	3.7137	4.0552

Note: Probabilities obtained in univariate analyses of variance.

* = P<.05
** = P<.01
*** = P<.001

Table 3

Sex and Field of Concentration by Initial Field of Interest

Field of Interest at First Enrollment	Total	Women in Humanities and Social Science	Women in Science, Math, or Engineering	Men in Humanities and Social Science	Men in Science, Math, or Engineering
Science, Math or Engineering	220 (52.4)	50 (26.9)	94 (84.7)	18 (34.6)	58 (81.7)
Humanities or Social Science	100 (23.8)	77 (41.4)	0	22 (42.3)	1 (1.4)
No field in mind	100 (23.8)	59 (31.7)	17 (15.3)	12 (23.1)	12 (16.9)
Total	420 (100.0)	186 (100.0)	111 (100.0)	52 (100.0)	71 (100.0)

Table 4

Level of High School Preparation by Sex and Persistence in or Defection from an Initial Interest in Science

	Women Who Reported an Initial Interest in Science		Men Who Reported an Initial Interest in Science	
	Majored in Science, Math, or Engineering (94)	Majored in Humanities or Social Sciences (50)	Majored in Science, Math, or Engineering (58)	Majored in Humanities or Social Sciences (18)
Advanced Placement Courses				
Humanities	46.8	36.0	48.3	33.3
Foreign Languages	16.0	16.0	10.3	00.0
Mathematics	45.7	28.0	46.6	27.8
Sciences	43.6	22.0	43.1	33.3
Advanced Placement Tests				
Humanities	40.4	26.0	41.4	27.8
Foreign Languages	17.0	12.0	03.4	00.0
Mathematics	27.7	08.0	36.2	16.7
Sciences	34.0	10.0	27.6	27.8
Exempted from UM courses				
Humanities	33.0	14.0	19.0	22.2
Foreign Languages	13.8	18.0	03.4	00.0
Mathematics	23.4	08.0	36.2	16.7
Sciences	29.8	10.0	27.6	05.6

Table 5

Factors Affecting Selection of Field of Concentration,by Sex and Field
(% rating factor as 4 or 5)*

	Total	Women in Humanities and Social Sciences	Women in Science, Math, or Engineering	Men in Humanities and Social Sciences	Men in Science, Math, or Engineering
	(420)	(186)	(111)	(52)	(71)
Family member	22.9	23.7	26.1	17.6	19.7
Teacher or counselor	23.1	28.6	15.3	28.9	16.9
Other adult	15.1	19.2	12.0	10.0	12.7
Friends or fellow students	28.4	29.4	28.8	23.5	28.6
College course(s)	77.3	82.8	69.1	86.6	69.1
Work experiences	39.6	41.3	42.3	29.4	38.0
Volunteer or travel experience	25.8	32.5	19.8	25.0	18.4
Your own talent in the field	79.0	86.0	74.7	75.0	70.0
Strong background in the field	53.6	56.2	54.0	31.3	62.0
Personal enjoyment, interest	91.6	94.6	88.1	92.3	88.8
Importance of field as preparation for intended profession or career	68.5	61.6	82.8	59.7	70.4

*Scale: 1= Not at all important ; 5=very important

Table 5A

Mean Ratings of Importance of Factors Affecting Choice of Field of Concentration
by Sex and Field

		Overall Mean	Women in Humanities and Social Sciences	Women in Science, Math, or Engineering	Men in Humanities and Social Sciences	Men in Science, Math, or Engineering
	Family member	2.4474	2.4919	2.5495	2.2549	2.3099
*	Teacher or counselor	2.3652	2.5676	2.1441	2.4808	2.0986
	Other adult	2.0122	2.1319	1.9352	1.9000	1.9014
	Friends or fellow students	2.6010	2.6413	2.5315	2.6078	2.6000
**	College course(s)	4.0955	2.2957	3.9273	4.1923	3.7606
	Work experiences	2.8561	2.9728	2.8649	2.4118	2.8592
***	Volunteer or travel experience	2.3723	2.7081	2.0631	2.3462	2.0000
***	Your own talent in the field	4.0979	4.3172	3.8468	4.0577	3.9429
**	Strong background in the field	3.3923	3.5351	3.2072	2.9216	3.6479
***	Personal enjoyment, interest	4.5000	4.6703	4.3636	4.4423	4.3099
***	Importance of field as preparation for intended profession or career	3.8732	3.7081	4.3091	3.5769	3.8451

Note: Probabilities obtained in univariate analyses of variance.

* = P<.05
** = P<.01
***= P<.001

Table 5B

Mean Ratings of Importance of Factors Affecting Choice of Field of Concentration by Field

		Overall Mean (420)	Humanities and Social Science Students (238)	Science, Math and Engineering Students 182)
	Family member	2.4474	2.4407	2.4560
***	Teacher or Counselor	2.3652	2.5485	2.1264
	Other adult	2.0122	2.0819	1.9218
	Friends or fellow students	2.6010	2.6340	2.5580
***	College course(s)	4.0955	4.2731	3.8619
	Work experience	2.8561	2.8511	2.8626
***	Volunteer or travel experience	2.3723	2.6287	2.0385
***	Your own talent in the field	4.0979	4.2605	3.8840
	Strong background in the field	3.3923	3.4025	3.3791
***	Personal enjoyment, interest	4.5000	4.6203	4.3425
***	Importance of field as prepartion for intended profession or career	3.8732	3.6793	4.1271

Note: Probabilities obtained in univariate analyses of variance.

*** = p<.001

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Table 6

Importance of Job Characteristics Reflecting Personal Values and Goals
(% rating each characteristic as 4 or 5)*

Job Characteristics	Overall Rating	Women in Humanities and Social Sciences	Women in Science, Math, or Engineering	Men in Humanities and Social Sciences	Men in Science, Math, or Engineering
A great deal of intellectual challenge	88.2	84.8	91.7	92.4	88.8
Opportunity to work for changes in society	55.3	56.5	52.3	61.6	52.2
Potential to earn a very high income	48.8	45.6	50.4	48.1	54.9
Potential to hold highly respected position	66.4	64.6	67.9	63.4	70.4
Wide availability of jobs	44.2	39.3	57.4	28.9	47.9
Not too much pressure or stress associated with work	17.6	16.8	16.6	25.0	15.5
Opportunity to work independently, with little supervision	61.3	63.1	56.0	69.3	59.1
Opportunity to work closely with colleagues	48.7	44.6	47.3	53.9	57.7
Opportunity to be helpful to people	75.0	73.3	77.0	78.8	73.2
Potential for flexible work schedule	51.6	56.5	53.7	50.0	36.7
Opportunity to be creative	70.9	69.6	63.3	75.0	83.1
Opportunity to take initiative	83.6	84.8	78.0	82.7	90.0
Opportunity to take responsibility	91.3	92.4	92.7	86.6	90.2
Opportunity to engage in tasks you enjoy doing	97.1	97.3	96.3	96.1	98.6
Opportunity to shape important programs or policies	59.1	60.3	53.2	65.4	60.6
No need for lengthy graduate training	16.4	19.2	12.0	28.0	7.2
Freedom to work on problems of your choosing	45.6	42.9	44.0	55.8	47.9
Opportunity to solve important problems	69.0	64.5	74.3	63.5	76.1
Chance to win recognition for significant achievement	45.7	45.9	50.4	44.3	39.4
Opportunity to create new knowledge	48.5	40.5	57.8	42.3	59.2

* Scale: 1=Not at all important; 5=Very Important

Table 7

Agreement with Criticisms of Science and Math Classes
(% indicating moderate or strong agreement)*

Criticism	Overall Rating	Women in Humanities and Social Sciences	Women in Science, Math, or Engineering	Men in Humanities and Social Sciences	Men in Science, Math, or Engineering
Science courses are more difficult than courses in the humanities or social sciences	52.7	40.4	70.9	41.1	64.3
Science courses are too time-consuming, with both lectures and labs to attend	48.7	47.0	56.4	43.2	45.1
Science courses involve too much solitary work	19.9	18.9	17.3	26.0	22.6
Students in science courses are too aggressive and competitive	45.0	42.3	48.2	47.0	45.1
Teaching assistants in science and math courses frequently have difficulty communicating with students	71.6	73.4	71.8	70.6	67.6
Science and math courses are not concerned with values	39.0	39.0	38.9	41.2	37.1
Science majors frequently have difficulty fitting into their schedules the electives they would like to take	48.1	36.4	60.9	36.2	65.7

*Scale: 1=Strongly agree; 5=Strongly disagree. Entries in table are percentages of respondents rating each criticism as 1 or 2

Table 8

Characteristics Rated as Self-Descriptive by Science and Non-Science Majors
(% rating each statement as 4 or 5)*

Section A	Science, Math, and Engineering Majors		
Statement	Total	Women	Men
	(169)	(101)	(68)
I have always enjoyed science	85.8	85.1	86.8
I have the talent for scientific work	84.5	82.2	88.0
A science background is necessary for the kind of career I want to pursue	87.5	86.2	89.7
I've been encouraged by my parents to go into science	52.0	56.4	45.6
I've been encouraged by my teachers to go into science	54.1	55.5	52.2
I think a scientific education will be useful in getting a good job	83.4	82.2	85.3

Section B	Humanities and Social Science Majors		
Statement	Total	Women	Men
	(231)	(181)	(50)
I never considered going into science	31.2	33.7	22.0
I have never liked science	12.5	13.8	08.0
I've done well in science, but other subjects interested me more	64.9	63.5	70.0
I don't need science for the career I want to pursue	65.0	67.5	56.0
My parents discouraged me from going into science	00.4	00.6	00.0
My teachers discouraged me from going into science	04.8	05.5	02.0
I don't have the talent for scientific work	22.2	24.4	14.0
I think a science major takes too much time and effort if you're not sure you'll use it	16.6	17.2	14.3

*Scale; 1=Does not describe me at all; 5=Describes me very well

Table 9

Factors Creating Problems for Women in Science
(% responding "Serious problem" for women generally and for respondent)

	Overall Rating	Women in Humanities and Social Sciences	Women in Science, Math, or Engineering	Men in Humanities and Social Sciences	Men in Science, Math, or Engineering
Long years of formal preparation					
a. For women generally	10.4	12.4	10.4	6.1	8.6
b. For respondent	14.5	15.4	10.6	32.6	5.9
Possible conflicts between career and family responsibilities					
a. For women generally	42.3	35.0	57.5	35.4	42.3
b. For respondent	22.0	21.4	37.5	7.0	9.0
View that women majoring in science or technical fields are unfeminine					
a. For women generally	17.7	15.8	15.1	31.3	16.9
b. For respondent	3.4	2.4	7.7	-	1.5
Lack of encouragement from teachers or counselors					
a. For women generally	33.3	35.0	33.0	27.1	33.8
b. For respondents	15.1	19.4	19.4	9.3	1.5
Lack of encouragement from family or friends					
a. For women generally	25.2	21.5	20.8	31.9	36.6
b. For respondents	5.2	7.1	3.8	7.0	1.5
Women's lack of confidence that they can handle the work					
a. For women generally	26.5	26.3	34.0	16.7	22.5
b. For respondents	14.4	17.5	16.5	14.3	3.0
Lack of information about careers in scientific field					
a. For women generally	20.9	25.6	24.5	12.5	9.9
b. For respondents	18.3	21.3	21.2	16.3	7.5
Lack of contact with women in scientific field					
a. For women generally	41.0	37.9	49.1	41.3	36.6
b. For respondents	25.3	29.0	32.7	7.5	14.9
View that scientists are cold and impersonal					
a. For women generally	16.1	15.2	15.9	18.8	16.9
b. For respondents	12.2	11.1	12.6	11.6	4.9
Aggressive, competitive attitudes of students in science classes					
a. For women generally	30.8	35.6	35.5	19.1	19.7
b. For respondents	30.6	37.8	31.7	19.0	17.9
Discriminatory attitudes toward women on part of teachers or others in scientific fields					
a. For women generally	36.8	38.6	36.4	39.6	31.0
b. For respondents	12.3	14.7	18.3	2.4	3.0